OPEN TYPES

Our discussion up to this point has concerned itself with chest wounds of the "closed" type; but it must be remembered that the "open" variety are much more serious than the closed, for they invite infection, cause mediastinal flutter, throw maximum strain upon the heart and lungs, and produce momentous symptoms. Whenever possible the open thorax should be converted immediately into a closed type and thereafter so treated. But if deep hemorrhage is present, and facilities are available, the wound should be extended, bleeders located and controlled, and the chest closed air-tight. Postoperatively pleural fluid generally accumulates, but this can be aspirated.

Contrary to what one might expect, a few patients with open chest wounds do exceptionally well even from the first. I recall a man who entered the hospital with a part of the lung protruding between his ribs. Fortunately, however, this portion of the lung sufficiently plugged the opening so that a pneumothorax did not occur, and he was without symptoms. The herniated lung was included in the suture approximating the muscles, and the skin was closed separately. Primary healing occurred and the patient was discharged on the tenth day. An x-ray made at that time showed no abnormality. This man has remained well and has been able to resume his usual occupation.

COMMENT

In all these cases of chest injury it is impossible to overstress the importance of proper treatment during the early stay in the hospital, and the necessity of close observation after discharge, if one is to hope for a satisfactory outcome.

In addition to the immediate and late thoracomechanical problems, one must give attention to the treatment of shock and hemorrhage and to the prevention of infection.

CONCLUSIONS

1. Traumatic pneumothorax and hemothorax are frequent complications of chest injuries. Treatment is determined by the severity of the symptoms: the flexibility of the mediastinum, the presence or absence of pleural adhesions, and the amount of shock or hemorrhage.

2. With pneumothorax, the air is withdrawn over a period of days so that the lung wound may have a chance to heal.

3. With hemothoraces, the blood is removed from the pleural cavity and replaced by air. The subsequent treatment is that of pneumothorax.

4. When signs point to an extensive lung tear which remains open, a thoracotomy is performed, bleeding controlled, the lung sutured, and the chest closed air-tight.

5. Contralateral traumatic atelectasis is, in our opinion, caused by the patient's position which allows the blood to spill from the injured into the uninjured lung. In many cases it can be prevented.

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CARBON DIOXID THERAPY*

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PROBABLY the earliest use of carbon dioxid as a respiratory stimulant was mouth-to-mouth insufflation, a procedure practiced from the earliest times to the present. Davies[1] quotes from the Old Testament (2 Kings, IV, 34-35) one of the first recorded instances of this method of resuscitation. It was not until 1908 that Hill and Flack[2] suggested the rational use of carbon dioxid in respiratory failure, carbon monoxid poisoning, and chloroform syncope. In 1920, Henderson, Haggard, and Coburn[3] recommended the inhalation of carbon dioxid to speed the excretion of volatile anesthetics.

CONTROL OF RESPIRATION

Respiration is controlled chiefly through a respiratory center in the medulla and through the carotid body. The medullary center is affected by hydrogen ion concentration, so that an increase in acidity stimulates respiration and allows excess acid to be excreted through the lungs as carbon dioxid, while a decrease in acidity causes suppression of breathing and retention of carbon dioxid. Carbon dioxid is particularly efficient as a central respiratory stimulant because it is more soluble and diffusible than other acids as, for example, lactic acid. Thus, it is the most important single factor in the central control of pulmonary ventilation.[4,5] Reflex control of respiration through the carotid body is determined by the oxygen content of its arterial blood supply. When the oxygen of this blood is below the usual arterial concentration, chemoreceptors in the carotid body transmit stimuli to the medullary center which result in an increase in respiratory volume.[6,7,8] There is, then, a delicately balanced dual system which controls pulmonary ventilation—directly through the respiratory center of the medulla when there is an excess or a deficiency of carbon dioxid or a change in the hydrogen ion concentration, or, reflexly, through the carotid body when there is a change in oxygen tension.

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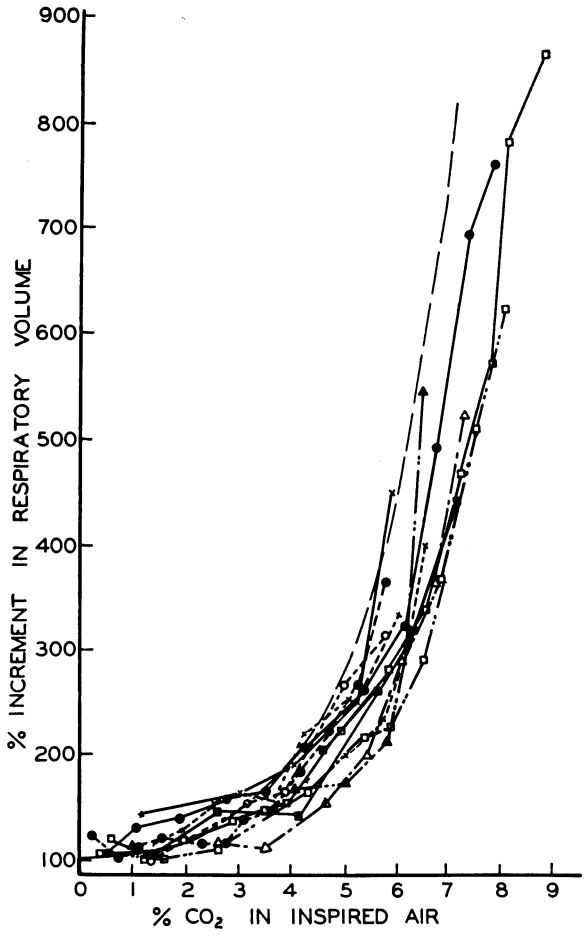

Fig. 1. Respiratory effect of breathing carbon dioxid in normal males. Data taken from Peabody[9] and Davies, Brow and Binger.[25]

RESPONSE TO CARBON DIOXID

The average response of normal subjects to varying concentrations of carbon dioxid is shown in a chart taken from Peabody's studies[9] (Figure 1). Four per cent carbon dioxid approximately doubles respiratory volume and 7 per cent increases respiration sevenfold. Concentrations of carbon dioxid above 7 per cent when inhaled for a few minutes are unbearable except in rebreathing experiments.[2] Concentrations of over 10 per cent carbon dioxid cause anesthesia and respiratory depression, and for this reason, we believe, as do others, that higher concentrations should not be used. In fact, a concentration of from 5 to 7 per cent carbon dioxid produces an adequate increment in pulmonary ventilation and is probably optimal. Under certain conditions the response to carbon dioxid is altered. In cardiac failure, Peabody has shown that the inhalation of 2 per cent carbon dioxid approximately doubles the volume of ventilation. Drugs depressing to the central nervous system decrease the respiratory response to carbon dioxid.

Opinions have differed widely as to the effect of variations in the oxygen tension on the response to carbon dioxid. The work of Eastman[10] and Selladurai and Wright[11] indicates that in states of severe anoxemia carbon dioxid is less effective as a respiratory stimulant than under normal conditions. At the other extreme, most observers have felt that the oxygen tension does not sensibly affect the response to carbon dioxid, provided adequate oxygen (that is, the usual amount of oxygen in the air at sea level) be present. Shock and Soley[12] have shown that, at high oxygen tensions, the respiratory response to a given concentration of carbon dioxid is greater than to the same concentration of carbon dioxid mixed with air. As can be seen in Table 1, 4 per cent of carbon dioxid in air increases the respiratory volume by 97 per cent, while 4 per cent carbon dioxid in pure oxygen causes a respiratory increment of 122 per cent.

It is surprising that hospitals still use tanks of 30 per cent carbon dioxid and 70 per cent oxygen for the purpose of resuscitation. Recent work has shown that in the treatment of schizophrenia carbon dioxid has somewhat the same effect as insulin shock, metrazol convulsions, and nitrogen inhalations. Himwich and coworkers[13,14] have demonstrated that in these three methods the oxygen uptake of the brain is decreased by about two-thirds, and they feel that the beneficial effects are due to cerebral anoxemia. It may well be that the inhalation of 20 to 30 per cent carbon dioxid disturbs the oxidation-reduction mechanisms within the cells. Loevenhart, Lorenz, and Waters[15] have suggested this as a possible explanation for the effects of inhaling high concentrations of carbon dioxid. In any case, it seems clear that 10 per cent of carbon dioxid is the highest concentration that should be administered for respiratory stimulation.

OXYGEN VERSUS CARBON DIOXID

In respiratory depression and anoxemia, oxygen is the necessary therapeutic agent. As long as the circulatory system is intact, adequate oxygenation of tissues can be maintained by continually supplying oxygen through the lungs. If the patient is breathing spontaneously, this can be done by having him inhale pure oxygen. If he is apneic, oxygen should be administered by intrapharyngeal or intratracheal insufflation. Administration of pure oxygen not only saturates the hemoglobin with oxygen, but also increases the oxygen in physical solution by approximately 2 per cent. If these facts are kept in mind in the treatment of asphyxiated patients, they will have a greater chance for recovery. However, there are still definite indications for the administration of carbon dioxid mixed with pure oxygen.

THERAPEUTIC USES OF CARBON DIOXID

Carbon dioxid is still the most important respiratory stimulant in general anesthesia. It may be administered by having the patient rebreathe his own carbon dioxid, or by giving it directly from a tank.* Another important application of carbon dioxid in anesthesia is its use to increase the elimination of volatile anesthetics during the recovery period as suggested by Henderson, Haggard, and Coburn.[3] It should also be remembered that carbon

* One of the reasons for the introduction of the carbon dioxid absorption technique by the anesthetists at Wisconsin General Hospital was the waste involved in anesthesia with gases unless inordinately high concentrations of carbon dioxid were allowed to accumulate in the semi-closed systems.

TABLE 1.—*Increase in respiratory volume of normal subjects (expressed in per cent) caused by breathing 1, 2, and 4 per cent CO_2 mixed with 21 per cent O_2 and 1, 2, and 4 per cent CO_2 mixed with 99, 98, and 96 per cent O_2, respectively. Each increase in respiratory volume represents the average effects of two tests with each mixture of CO_2 and O_2.*

Combinations Used	Subjects	Mean Increase in Respiratory Volume in Per Cent
1 per cent CO_2 with 21 per cent O_2	17	14.0
1 per cent CO_2 with 99 per cent O_2		28.4
2 per cent CO_2 with 21 per cent O_2	12	34.2
2 per cent CO_2 with 98 per cent O_2		52.8
4 per cent CO_2 with 21 per cent O_2	15	101.3
4 per cent CO_2 with 96 per cent O_2		121.1

dioxid within therapeutic ranges elevates the blood pressure.

Inhalation of 7 per cent carbon dioxid and 93 per cent oxygen probably constitutes the best therapy for carbon monoxid poisoning. The mechanism of action is threefold: the oxygen overcomes the anoxemia, and the carbon dioxid not only stimulates respiration, but also aids in the breakdown of carbon monoxid hemoglobin by increasing acidity.[16,17]

In selected cases, the inhalation of carbon dioxid is valuable postoperatively in preventing atelectasis and pneumonia, for it expands the lungs fully and loosens the bronchial secretions. King[18] has found that in unselected cases the incidence of postoperative pulmonary complications is not changed by this procedure.

Mosso first reported the use of carbon dioxid for the relief of the symptoms of mountain sickness. At high altitudes, lack of oxygen causes a compensatory hyperpnea and secondary excessive loss of carbon dioxid through the lungs. Mountain climbers have found a practical application of this knowledge in the use of carbon dioxid for the prevention of periodic breathing, especially at night, in high altitudes. Gellhorn[19] reported that 3 per cent carbon dioxid relieves all the symptoms of oxygen want until the concentration of oxygen in the inspired air falls below 8.5 per cent.

One of the common physiologic manifestations of the anxiety states is the hyperventilation syndrome.[20] Overbreathing from any cause results in excessive loss of carbon dioxid from the lungs and consequent tetany. This can be relieved almost immediately by inhalation of 3 to 5 per cent carbon dioxid. The "hysterical" patient is often in a state of hyperventilation tetany, and carbon dioxid should be considered for the temporary symptomatic relief of this condition. It may be added that the anxiety of patients undergoing operative procedures under local anesthesia often produces this phenomenon.

Carbon dioxid may be used in shock to raise the blood pressure and to increase the venous return to the heart. However, Yandell Henderson's[21] original theory that acapnia causes shock has been modified by more recent work which implies, on adequate grounds, that transfusion and other procedures are more important.

CONTRAINDICATIONS TO CARBON DIOXID

In many clinical conditions lack of oxygen, rather than deficiency in carbon dioxid, is the primary disturbance, and consequently the uses of carbon dioxid are limited. Respiratory stimulation is usually required in order to increase the amount of available oxygen; therefore, oxygen should always be given alone or with carbon dioxid. As long as cellular respiration continues, carbon dioxid is produced. In states of severe anoxemia, the sensitivity of the respiratory center to carbon dioxid is apparently reduced.

Eastman[10] has shown that in the apneic newborn baby an excess of carbon dioxid is present. Therefore, oxygen should be administered rather than carbon dioxid. On the other hand, some babies may initiate respiration, but then have periods of difficult breathing and cyanosis. When these conditions are caused by the incomplete expansion of expansible lung tissue (Farber and Wilson[22]), deepening of the respiration by carbon dioxid may be valuable.

Davies[1] and Boothby[23] state that carbon dioxid is contraindicated in laryngeal obstruction because it causes laryngeal spasm. A recent article,[24] published by the Council on Pharmacy and Chemistry of the American Medical Association, reiterates the warning against inhalation of carbon dioxid in clinical conditions associated with pulmonary edema, since the increased negative pressure within the thorax may accentuate the congestion in the alveoli. Finally, since the inhalation of carbon dioxid in concentration of 4 per cent or more causes a rise in blood pressure, it should not be used in hypertensive patients.

SUMMARY

When carbon dioxid is administered as a respiratory stimulant, it should not be given in concentrations of more than 5 to 7 per cent. Carbon dioxid should always be mixed with oxygen when it is used as a respiratory stimulant. The respiratory response to carbon dioxid is enhanced in the presence of high concentrations of oxygen. However, even with high concentrations of oxygen, 20 to 30 per cent carbon dioxid probably disturbs the oxidation reduction mechanisms of cells.

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ROENTGEN THERAPY IN THE TREATMENT OF ABSOLUTE GLAUCOMA*

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IN spite of the large background of clinical and experimental information which has accumulated during the past four decades, roentgen therapy is still looked upon by many as an empirical and radical therapeutic procedure, to be used "as something to try" when other measures, however ineffective and sometimes less rational, have failed.

First employed for the treatment of pathologic lesions in 1896[4] in a case of mammary carcinoma, it was rapidly adopted and widely used by professional and nonprofessional men alike. All types of diseases, both benign and malignant, were subjected to irradiation. There was no knowledge of its effect on living tissue, no means of controlling the quality of the beam, no accurate method of measurement, and no precedent to warn of the immediate or latent dangers of overdosage. As a consequence, many disastrous tissue reactions or "burns" occurred, giving rise to a fear and prejudice of its use which even now lingers in the minds of many.

Today the roentgenologist can measure accurately, in an internationally accepted unit, the "roentgen" or commonly called "r" unit, the amount of x-ray produced by a given piece of apparatus in a given period of time. The quality can be governed by control of kilovoltage and filtration, thus removing all but the "human equation" hazard incident to irradiation. It is true that the roentgen ray can only be used safely by one who has a knowledge of its characteristics and of its clinical application. In the hands of the untrained it is, and will remain, a most dangerous method of treatment.

INCREASING USE OF ROENTGEN THERAPY IN OPHTHALMOLOGY

That roentgen therapy is becoming more widely used in ophthalmology is attested by the fact that more and more cases are being referred to the radiologist for treatment, and a voluminous literature is accumulating on the subject. Aside from many types of intra- and extra-ocular neoplasms, roentgen therapy is of value in various ophthalmic disorders and infections. Many believe that some should be treated by radium, and others by the roentgen ray; but it is the writer's opinion that there is no evidence to support the claims of one over the other. Certain factors may determine which source it is most desirable to use in a given case, but the clinical results should be the same with either. Some of the conditions in which radium or roentgen rays have been successfully used are listed: Absolute glaucoma[10-14]; blepharitis[9]; blastomycoses[6]; cellulitis, orbital[2]; choroiditis[3]; corneal ulcers and opacities[2,3]; conjunctivitis, follicular,[3] tuberculous,[12] vernal[3]; entropion[6]; erysipelas[6]; granuloma[6]; hemorrhage, traumatic[3]; iritis, simple and tuberculous[2,3,8]; keratitis, simple ulcerative, interstitial[1,2,3,9]; leukoma, combined with surgery[5]; maculae[5]; pannus, trachomatous[1,3,5]; pterygium,[2,3] postoperative recurrent[5]; opacities, vitreous[2,3]; sclerositis and episclerositis[3]; staphyloma[5]; sympathetic ophthalmia[2]; trachoma,[1,2,3,5] "x-ray almost a specific," acute and subacute; traumatic ulcers, infected[3]; and uveitis.[1,3]

FIRST USE OF IRRADIATION IN GLAUCOMA

Irradiation was first used in the treatment of glaucoma in 1906.[10] Radium was so applied that

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